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From the fellow
traveller in Iceland
J. F. Campbell
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ON THE

GLACIAL PHENOMENA

OF

THE YORKSHIRE UPLANDS.

BY

J. R. DAKYNS, Esq.

THE Carboniferous hills that form the central axis and backbone of Northern England sink beneath the Triassic plain near the town of Derby. Between Derby in the south and Wensleydale in the north,

this line of hills is broken through by the valleys of the Wye, in Derbyshire, and of the Calder and the Aire, in Yorkshire.

In Derbyshire and the part of Yorkshire south of the Aire basin, no glacial drift has been found on the eastern slope of the chain, save where the latter is broken through by the above-named valleys. Thus in Derbyshire plenty of drift occurs in the valley of the Wye and in that of the Derwent below its junction with the Wye, as if some of the drift that is so plentiful on the western slope of the Pennine chain had come eastward through the Wye valley; but north of the Wye none is found in Derbyshire on the eastern slope of the chain. Again, some boulders of transported rocks, granite, and other foreigners are said to have been found in the bed of the Calder; but no drift-deposits have been found in the Calder basin east of the anticlinal axis, save one patch of Boulder-clay at Mixenden, some miles above Halifax, quite at the edge of the driftless area. The boulders above mentioned would seem to have been washed out of the drift of Lancashire. On the other hand, the western slope of the Pennine range is everywhere thickly covered with drift nearly up to the level of the watershed. But when we cross the Oxenhope moors, from the basin of the Calder into that of the Aire, the state of things is very different. The basin of the Aire and the whole country northward is thickly covered with drift indifferently on the east and west.

The drift of Lancashire and Cheshire is considered to be marine, for the following reasons: in the first place, it contains far-transported rocks, such as granite; in the second place, it is prolonged through the Wye valley, while nowhere else is drift found on the eastern hills, thus showing it had floated through the gap.

I will now describe certain general phenomena in connexion with the drift of the Aire basin and the country northward, from which it will appear, I think, that the mass of it is due to land-ice.

In the first place, this drift contains no foreigners—that is, no stones that may not have come from the rocks of the basin where it is found. Thus in the basin of the Aire, east of Skipton, the stones are entirely Carboniferous grits, sandstones, and limestones, all which rocks occur in the basin of the Aire; while north of Skipton, on the edge of the great plain that stretches to the Ribble, a few small, much-worn Silurian pebbles are occasionally found, which have doubtless come from the Silurians of Ribblesdale.

Again, in Wharfedale we have nothing but Carboniferous rocks in the drift, with one exception: this is near Threshfield, where Silurian erratics do occur; but they are special to that locality, and are found where the valley, ceasing to be a narrow dale, opens out into a plain reaching as far as the Ribble. In the high dale the drift is entirely composed of local rocks.

It would seem, then, that whatever brought the drift was some agent acting locally. It was not, then, either ice floating from afar or necessarily a universal ice-sheet overriding the watersheds, though I shall presently give reasons for thinking there was such an ice-sheet.

Further, in Wharfedale and its affluents, in Wensleydale (as far as I know) and its affluents, the following phenomena are universal.

Wherever two large valleys join, there is a great pile of drift heaped up in the angle between them, on the gable end of the bounding hills. This is seen at the junction of Wharfe- and Littondales—again at Kettlewell, at the junction with the main valley of a large gill descending from Coverhead, and in other places—also above West Burton, on the gable end between Walden and Bishopdale. This points unmistakably to glaciers descending the two valleys, and throwing down together their inner lateral moraines. Moreover, the rock is apt to be montonnée where the pressure of a glacier would be greatest. One case, in particular, I can mention: just above the hamlet of Kilnsey is a conspicuous scar of solid limestone; the northern face of this rock is beautifully smoothed; and this is just where the Wharfedale glacier would press that coming down Littondale against the side of the valley. We should doubtless see more polished and scratched surfaces, were it not that limestone, when not covered with clay, yields so rapidly to the action of the weather; but we do sometimes find scratches and grooves, and they are always along the valleys. There is an excellent example, for instance, of grooved and polished limestone preserved under a bed of clay near Kettlewell.

Another general phenomenon is the following. Where a barrier of rock crosses a valley, the drift is piled up in mounds against and over the rock, as if deposited by a glacier against a barrier; and above such a barrier there is generally a wide spread of alluvium, as if a lake lying in a rock-basin had been silted up. This is nearly, if not quite, universal.

Again, where we have such a spread of alluvium, we do not see the solid rock in the bed of the stream between the two ends of the alluvium; when we do get the rock in the stream, it is near the beginning or the end of the alluvium, and there, too, a mound of drift crosses the valley. This, again, points to rock-basins and local glaciers depositing a terminal moraine against the rock barrier. It is a difficult matter positively to prove the existence of a rock-basin; but when, over and over again, we find a spread of alluvium above a rock barrier, and that no solid rock shows in the course of the stream through the alluvial flat, save at its ends, the beds all the while retaining their usual dip, this amounts by a cumulative argument nearly to a proof thereof.

A great deal of the drift is as angular as ordinary moraine-matter might be expected to be; but a great deal of it is also composed of rounded pebbles, well scratched; and yet these two cannot be separated from one another; and the rounded and scratched drift has often the characteristic shape of moraine, whether terminal or lateral. But rocks riding on the surface of a glacier, and shed therefrom, will be neither rounded nor scratched. The latter kind of drift, then, did not so come. But rocks sticking in the bottom of a glacier will be both rounded and scratched, and the more so the further they have travelled. So we must consider many of our moraines to have been shed from the body of the glacier. It struck me, too, that the further we go from the parent hills, the more generally rounded and

scratched does the drift material become. This is again an argument in favour of the glacier origin of the drift.

There is another point to which I wish to direct the attention of geologists, that we may learn whether there is any thing in it or whether it is merely a local accident. I was very much struck with it when, three or four years ago, I first became acquainted with the great drift-area. It is this: the drift is very often found entirely on one side only of a valley, and that always the same side with reference to the source and origin of the drift, viz. on the lee side of hills, as drifted snow or any other drifted material. I will give some examples. The drift of the Aire basin doubtless came from the north and north-west. Now the south side of the Aire valley near Keighley is comparatively free from drift, while the north side is thickly covered with it. Again, take the Worth valley, which runs to the N.E.; the east side is free from drift, while the west or lee side is thickly covered. The same appeared to me to be the case with Wharfedale where it runs east and west, viz. that the north side was thickly covered, while the south was free. If it should turn out that this is any thing more than a local accident, it points to a universal ice-sheet and to the drift being moraine profonde deposited thickly on the lee side of hills while the ice-sheet passed over it, dropping it in its course, whereas on the exposed side the ice, as it ascended the slope, swept every thing before it. Of course, such valleys as lay in the direction of the ice-flow will not have this contrast of sides.

Besides the scratched gravels, we have also in certain places mounds of water-worn gravels arranged in confused heaps, often enclosing hollows, known by the name of Kames or Eskers. These kames bear a distinct relation to the valley; they occur at certain parts only of the valley, and were evidently deposited in the bottom of it; they form irregular mounds, sometimes quite blocking up the valley; they consist of stones that have been once scratched, but whose scratches have been worn off, doubtless by the action of the water in which the kames were deposited; so that the kames are either rearranged drift, or consist of drift deposited in the sea (for lakes are here out of the question) and which got its scratches effaced in the process of deposition. That the pebbles were once scratched is shown by the faint traces of scratches that sometimes occur.

From the way in which kames pass gradually into scratched gravels, and from the definite position they occupy in the valley, it seems to me probable that in many cases kames are merely the result of moraines deposited in the sea instead of on land.

It seems to me that the long straight ridges that run across hills without any reference to contours, and which are also called kames, are something quite distinct from the irregular valley-mounds just described.

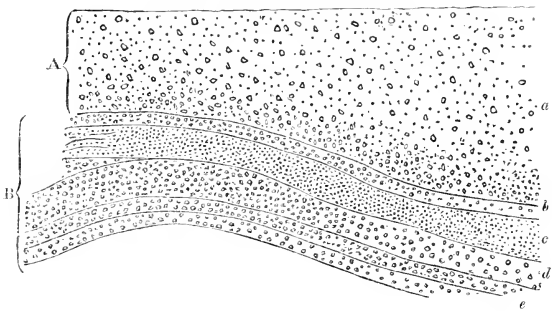
That these valley kames are due to sea-action is also shown by the fact that the cross-bedding of the sand dips up the valley as well as down it. This implies a current setting up the valley. When the

land stood low enough for the kames at Bingley to be deposited, the valley of the Aire would have been a frith, through which the tide may have set in opposite directions alternately, and thus the sand might be bedded both up and down dale. I can see no other way than by a tidal current setting backwards and forwards through a strait in which sand and gravel can be deposited with a dip both up and down dale.

The close connexion of kames with ordinary scratched drift is well seen in the vale of York. The western side of that vale consists of low undulating hills of drift. This drift is sometimes a well-scratched deposit of typical Boulder-clay, containing intercalated seams of fine sand and gravel, or a deposit of scratched pebbles too stony to be called Boulder-clay; the true Boulder-clay and the gravel passing gradually into one another. At other times the beds consist of stratified gravel, with here and there a faint trace of scratches that once existed but are now all but effaced. These gravels have the characteristic shape of kames; they either form long ridges, nearly straight, or are arranged in confused heaps surrounding hollows; but the scratched and the unscratched gravels are quite inseparable from one another.

In some gravel-pits near York, the structure of these kames is well seen. There we have, at the Coplesham gravel-pit, the following section:—

Section in Coplesham Gravel Pit.



a. Strong clay. *b*. Gravel. *c*. Sand. *d*. Gravel. *e*. Gravel.

The upper part (A) consists of a stiff, brown, unstratified clay containing a few scattered pebbles in its upper part, but choke-full of stones in its bottom, where it rests on the lower bed (B), which is a well-stratified gravel and sand arranged in the shape of a ridge, the beds dipping away on both sides from the crown of an arch.

I saw no scratched stones here; but corresponding stratified gravels on the other side of the Ouse contain numerous well-glaciated

boulders and pebbles in their lower part, where they seem to be passing downwards into true boulder-gravels.

The stones in the clay (A) were too dirty for me to see whether they were scratched or not; but it has the look of a true Boulder-clay. As far as the York sections go, then, the kames lie between two Boulder-clays; they would thus seem to be the equivalents of the middle drift, sands, and gravels of Lancashire.

They contain mammalian remains.

I think, then, that there is evidence for the following series of events:—At one time the Yorkshire hills were covered with continental ice, as Greenland is now; the vale of York was under water, and formed an arm of the sea into which the great glacier descending from the hills discharged its moraines, which were rolled about by the tides and deposited as kames; and subsequently, when the ice no longer reached the coast, the previously deposited drift would be rearranged by the tidal currents into kames; perhaps the land may have sunk gradually, so as even to bring new drift material within the action of the sea. At all events the land at one time stood low enough (say 400 feet below its present level) to allow of the valley of the Aire becoming a strait through which the tide played.

The climate ameliorated, perhaps as the land went down, till the universal ice-sheet vanished; but the great dales, such as Wharfedale, Wensleydale, Ribblesdale, &c., and their affluents had each a glacier descending it; these debouched at first in the sea, which filled the dales as the sea does the Norwegian fjords, to the height of 600 or 700 feet; subsequently the glaciers retired from the sea-level and finally vanished.

Why during all this time there should have been no glacial deposits formed on the eastern slope of the Pennine hills south of the Aire basin, is a very puzzling matter. I can only pretend partially to account for it by the following considerations. In the first place, the further south we go, of course, *cæteris paribus*, the milder the climate becomes; and every mile makes some difference. In the second place, though one wonders why, if there were glaciers descending from Whernside 2300 feet high, there should not also have been glaciers on Kinder Scoot, 2000 feet high; yet, though the extreme points in the southern country are nearly as high as some of the highest hills in the north, the general level of the country is lower, and there is also not so much high ground superficially. And lastly, when the land stood about 1200 feet lower than it now does, (and the Lancashire drift in places reaches nearly as high as this), what remained above water would be such a narrow belt of land that there may well have been no land-ice. At the same time the submergence was not great enough to allow ice to float from the northern area laden with drift, as the watershed between the Aire and Calder is 1350 feet above the present sea-level. Perhaps the submergence was not even as great as 1200 feet in the Aire basin: we have evidence, in deposits of sand on the hill-side, of a submergence of 1000 feet; but that is the most I know of.

Discussion.

Prof. Ramsay agreed with the author as to the existence of these rock-basins in the Yorkshire area, and as to the absence of marine drift on great part of the slope of the Pennine chain. The terminal moraines had to some extent become obscured by the washing-in of soil by rain; but their ancient existence in many of the Yorkshire valleys was indisputable. The features of the country were, moreover, in many instances such as could not be reconciled with the deposition of the drift by marine action.